

**WIPO****PatentScope**

Activities & Services

[Search](#)[Contact](#)[Home](#)[Español](#) · [Français](#)[Home](#) > [Activities & Services](#) > [PatentScope](#) > [Patent Search](#)

[Home](#)
[About Patents](#)
[Patent Search](#)
 [Content](#)
 [Terms & Conditions](#)
 [Glossary](#)
 [Other Collections](#)
[PCT Resources](#)
[PCT Electronic Filing](#)
[Patent & Technical Information](#)
[Statistics](#)
[Law of Patents](#)
[Meetings](#)
[E-mail Updates](#)
[Contact](#)

Related Links

[International Patent Classification](#)
[Natural Language IPC Search](#)
[Standards & Documentation](#)

(WO/2004/008259) MECHANICAL OSCILLATOR SYSTEM[Biblio. Data](#)[Description](#)[Claims](#)[National Phase](#)[Notices](#)[Documents](#)

MECHANICAL OSCILLATOR SYSTEM The present invention relates to a mechanical oscillator balance and balance spring for use in horological mechanisms (e. g. timekeeping devices) and instruments. It is thought that it will be particularly applicable to the oscillator system in a mechanical watch. The present invention is not limited to this.

Previous mechanisms use metal alloys, in particular Fe-Ni or Ni, Cu-Be, Au-Cu alloys, for the balance. At its most general, in one of its aspects, the present invention proposes that the balance is made of a magnetic ceramic material and the balance spring is non-magnetic and is made of a composite material (including thermoset and thermoplastic polymers, esters and phenolic based resins), carbon ceramic material.

In contrast to metals, the above materials are non-susceptible to the effects of magnetism-induced damping and magnetically induced change of the Young's modulus. These materials have characteristics which are better than metals and so a mechanical oscillator system having a constant oscillator frequency with temperature can be made. Variation with temperature of the balance spring of the above materials may be less susceptible to internal mechanical stress (e. g. of the Young's Modulus, allowing amplitude to be maintained by the balance and a higher frequency) and therefore a more accurate horological mechanism or precision instrument than a metal spring.

The balance spring is arranged to oscillate the balance.

Preferably the balance is a balance wheel; the balance spring may be arranged inside the circumference of the balance wheel so as to oscillate the balance wheel back and forth about its axis of rotation.

The balance may be coupled to an escapement mechanism for regulating rotation of an escapement (e. g. coupled to the hands of a watch), as is also conventionally known.

Preferably the balance spring works in flexion to oscillate the balance, most preferably excluding the balance spring is preferably not relying on strain or shear properties for the repeated stresses during its (relatively rapid) oscillations. Preferably the balance spring coils are not in contact with each other, a gap between adjacent coils. This eliminates or reduces friction and allows the successive coils to move independently of one another.

While the main body of the balance is made of a ceramic material, it may have small appendages made of a different material.

Considerations relating to the oscillator frequency and in particular its variation with temperature are discussed.

The accuracy of a mechanical watch is dependent upon the specific frequency of the oscillator balance wheel and balance spring. When the temperature varies, the thermal expansion of the balance spring, as well as the variation of the Young's Modulus of the balance spring, change the oscillating system, disturbing the accuracy of the watch. The inventor has noticed that in approximately three quarters of the variation is due to thermal or magnetically induced changes.

[\[Printable version \]](#)

Methods for compensating these variations are based on the consideration that the specific exclusively upon the relationship between the torque of the balance spring acting upon the inertia of the latter as is indicated in the following relationship T : the period of oscillation, I : the moment of inertia of the balance wheel, G : the torque of the balance spring.

The moment of inertia of the balance wheel is a function of its mass m and its radius of gyration r .

The torque of the balance spring is a function of its dimensions: length h , thickness e and Modulus E . The length of the balance spring (which may be helical or spiral form) is the whole length, as distinct from e , e. g. a top to bottom measurement that varies according to the space.

The relationship is therefore written: Temperature variations influence T (the period of oscillation) through the effects of expansion and contraction of the system (balance spring and balance wheel) h and e and r for the balance wheel whose mass m remains constant.

It is known how to compensate for the effects of expansion on h and e . However the period T varies with variations of r and E in keeping with the relationship expressed by: These two terms are r and E .

It is necessary that this relationship should remain as constant as possible (so as to keep T constant).

Fe-Ni metal spring alloys render an approximate solution when the alloy is perfectly demagnetised; if the alloy is not perfectly demagnetised, the relationship is no longer constant: changes.

The currently employed metal alloys for balance springs show an increase in E (which is compensated by an increase in h and e) also in for an increase in temperature, over the ambient temperature range up to The balance spring employed in precision watches are of an Au-Cu alloy with a coefficient of thermal expansion which compensates for changes in the Young's modulus of the balance spring.

In summary, the currently used metal alloys despite compensation, only allow for the stability of T over a narrow temperature range and only when the balance spring alloy remains unmagnetised (employing a Fe-Ni balance spring may be stopped by a sufficient magnet).

Preferably the balance spring material comprises continuous fibres extending along the length of the spring from one end of said spring to the other end of said spring.

As the fibres are continuous extending along the length of the balance spring from one end to the other, the expansion of the spring which the spring expands (or contracts) with an increase in temperature can be controlled by the appropriate choice of the fibre material.

Preferably the continuous fibres are part of a composite material, although it is possible to have continuous fibres in a non-composite material (i. e. without a matrix, e. g. long ceramic fibres).

Where the material is a composite material, preferably the matrix phase comprises a polymer (as discussed above), carbon or a ceramic. In the case of a composite material with ceramic fibres, the continuous fibres extending along the length of the spring from one end of the spring to the other end of the spring, or smaller fibres that do not extend all the way along the spring.

Where ceramic fibres are used (with or without a matrix), it is important that the ceramic is a ceramic which is preferably, but not necessarily, the balance spring ceramic is Alumina-Silica-Boria. Fused quartz can also be used for the balance.

Preferably the thermal coefficient of expansion of the balance and the thermal coefficient of expansion of the balance spring, in the direction along the length of the balance spring, are of opposite sign and of similar magnitude (i. e. the difference in magnitude between the two is not more than a factor of 6 and the coefficients should not be greater than 10). In this way expansion of one can be compensated for by the other. For example, if said thermal coefficient of expansion of the balance spring is negative and the thermal coefficient of expansion of the balance is positive then with an increase of temperature r increases and in accordance with equation [2] these effects combine to assist in compensating for the variation of the period of oscillation T .

Preferably said coefficients of expansion are both very small. For example preferably the coefficients of expansion are both less than 10 ppm/°C.

Preferably said coefficient of expansion are both very small. For example preferably the coefficient of expansion of the balance is positive and less than and the coefficient of thermal expansion of the balance spring in the direction along the length of the balance spring is negative, but greater

The variation of E (Young's Modulus) with temperature is also important and is determined by a coefficient which is a measure of the unit change in Young's Modulus per unit increase in temperature

Preferably the thermoelastic coefficient of the material of the balance spring is negative ; and the temperature range 0 to 60 degrees Celsius.

In general, the formula for timekeeping changes (U) consequent upon a rise in temperature tends to zero when suitable values of α_1 (balance coefficient of thermal expansion), α_2 (balance spring coefficient of thermal expansion) and the thermo-elastic coefficient are selected by selection of appropriate materials

The tolerances represented by small (e. g. less than 6 and a small thermo-elastic value allow to be kept low.

Preferably the continuous fibres are ceramic fibres or carbon fibres, most preferably carbon fibres. Graphitic carbon structure has a negative longitudinal coefficient of thermal expansion and may for example be produced from a "PITCH" precursor or a polyacrylonitrile "PAN" precursor

The fibres may be laid parallel to each other along their lengths, or may be twisted together. The matrix modulates the coefficient of thermal expansion and Young's Modulus of the balance spring. It is useful where the fibres have a high and the matrix a low Young's Modulus or coefficient of thermal expansion

Preferably the coefficient of thermal expansion of the balance spring material in the direction of the balance spring is linear up to 700° Kelvin. This allows the system to be very stable in the arrangement and compensate for thermal variations over a large range. Preferably said coefficient of thermal expansion is

Preferably the damping of the modulus of elasticity of the balance spring is of the order of 0.1

Preferably the density of the composite material of the balance spring is less than

Preferably the balance is formed by high precision injection moulding.

Further aspects of the present invention also provide a horological mechanism or other precision instrument comprising the above described mechanical oscillator system.

An embodiment of the invention will now be described.

A mechanical oscillating system for use in a horological mechanism or other precision instrument, in the form of a balance wheel, and a balance spring arranged to oscillate said balance wheel.

The balance wheel is made of a non-magnetic ceramic for which the coefficient of thermal expansion is less than +6 most preferably less than 1 Quartz is one example of a suitable material.

Preferably high purity fused quartz is used, fused quartz has a coefficient of thermal expansion of +5.2 ceramic materials include Aluminium Nitride (+5.2), Alumino-Silicate-Glass Boron Carbide (+0.75), Silica (+0.75), Silicon hot-pressed or reaction bonded (+3.5) and Zirconia (stabilised) ; the numbers indicate the order of magnitude of the coefficient of thermal expansion of these materials in the direction of the balance wheel may preferably be by high precision injection moulding.

The balance spring is shaped into an Archimedes flat spiral or helicoid form. It is made from a composite comprising continuous carbon fibres which are either twisted or laid parallel to each other, the lengths of fibres which extend from one end of the spring to the other along the length of the spring are derived according to the stiffness required from the precursor pitch (a mixture of thousands of hydrocarbon and heterocyclic molecules) or polyacrylonitrile "PAN" (derived from a carbon graphite) fibres are coated and set in a matrix phase of polymer (thermosetting polymer, thermoplastic polymer, phenolic base resin etc), ceramic or carbon. The composite material acts in a flexural manner. The elasticity of the fibres is between 230 and 250 GPa. The composite has both a lower density less than 2.0 g/cm³ and its Young's modulus of the order of (0.001 to 0.01) Pa, both less than the currently employed materials

Its thermal expansion coefficient (α) in the direction along the length of the spring remains below zero, and is greater

This composite material is non-magnetic and obviates the negative effects of magnetism. The thermal expansion α of the spring is negative and acts in parallel with the spring's Young's modulus E with a rise in temperature and is therefore negative (normal).

The values of the coefficients of thermal expansion (the α coefficients) for the spring and the mass are small and of opposite sign which further assist in the compensation for temperature variations.

The α coefficient of the spring remains the same over a wide temperature range, and the mass represents only a small part of the total stable temperature range.

Thus, following the relationship: the numerator does not increase in value as is the case with temperature increases because the α coefficient of the fibre composite in the axial sense is negative and diminishes.

The denominator also diminishes when the temperature rises because the thermoelastic coefficient ν is negative (normal). Furthermore the height (h) and thickness (e) of the carbon fibre-matrix composite increase with temperature which also counteracts the decrease in Young's Modulus E with rise in temperature.

By this combination of materials and their mechanical properties it is possible to obtain both stability. The damping effect of the modulus of elasticity is one tenth of the value of the current damping and the reduced energy losses due to the decreased damping and density of the material allow maintaining stable amplitude and a significant increase in frequency and significantly reduce the oscillator system.

As has been explained above the present invention can be applied to a conventional mechanical time keeping device such as a watch. An example of a conventional mechanical oscillator system device is illustrated and described on pages 194 to 195 of "How Things Work", volume 1 published in the UK, which is incorporated herein by reference.